REGIONAL RESEARCH STATION
MINISTRY OF AGRICULTURE
NORTHERN REGION
NIGERIA

TECHNICAL REPORT NO.14

1960.

COMMONWEALTH MYCOLOGICAL
29 JUN 1961

REGIONAL RESEARCH STATION

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NOTES ON TOMATO LEAF SPOT CAUSED BY *SEPTORIA LYCOPERSICI* SPEG.

by

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1960

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INTRODUCTION.

Tomatoes grown during the 'rains' are attacked by a number of leaf diseases amongst which that known as 'leaf spot' is in the first rank and is frequently the limiting factor in the growth of the crop. This disease is pan-tropical and is known from reports from other parts of the world to affect a number of other solanaceous crops and weeds.

Symptoms.

In Nigeria, the disease commonly appears as the first fruit truss is developing, but may theoretically, attack the plant at any stage of development. The terminal leaflet of the oldest leaves is usually the first to show symptoms; these are in the form of small black, water-soaked, roughly circular spots varying from sub-microscopic to 2 mm in diameter. The spots tend to be concentrated towards the tip and margins of the leaf.

At a later stage, these symptoms appear in the lateral leaflets and chlorotic haloes surround the spots.

Later still, necrosis spreads progressively from the terminal leaflet, lesions appear on the rachis and petiole and this is followed by premature desiccation and abscission of the leaf. This exposes the fruit excessively to sunscald and thus affects quality in addition to affecting yield.

The fruit and main stem are rarely attacked.

The Causal Organism.

The causal fungus is ~~an ascomycete~~ Septoria Lycopersici, whose pycnidia, (spore bearing vessels), are present in the lesions. Spores are spread by rain splash, wind blown water or handling of the plants. Optimum temperature for development is thought to be 80°F, though details of the disease cycle of the West African form of the fungus have yet to be checked. The onset of the dry season or starvation of the plant checks development of the disease.

Control Measures.

Partial control may be effected by such compounds as Zineb and Maneb, the former having been used with partial success at Samaru. Frequent spraying is, however, required and more promising results have been obtained from varieties which have some resistance to the disease. A more detailed description of the organism, its life cycle and control measures, will be given elsewhere.

Resistant Varieties.

It is the main function of these notes to present some results of investigations on a small collection of varieti of varying degrees of resistance to the disease. In particular, the relationship between yield and degree of infection has been investigated.

MATERIALS AND METHODS.

The material for this study was a small plot of twenty-seven varieties, which had been planted in systematic order in single rows 2½ feet apart in the row, and twelve plant per row. They were sown in pots on 30 June 1959 and transplante on 30 July 1959. The soil (a savanna ochrosol consisting of reddish brown clay-loam of imperfect drainage, Samaru Series C) was given a dressing of 4 cwt of superphosphate and 2 cwt of sulphate of ammonia per acre. Staking was according to local practice.

The Varieties.

The varieties used are divisible into three groups: within the first two the lines are interrelated but the third group is a heterogeneous collection of lines of incomplete pedigree and origin. The varieties listed in Table I are in order of planting.

Table I.

Varieties of Tomato used in the Experiments.

Group 1.

Bot. Samaru Acc. No.	Charleston Ref.	
3520s	2933A	Lines derived from L.esculentum X L.hirsutum and resistant to S.lycopersici (Andrus and Reyna 1945). Also reputed to be immu to Fusarium wilt and Stemphyliu leaf spot. (Received March, 195 from Dr. C.F. Andrus, Southeast Vegetable Breeding Laboratory, U.S.D.A. (Agric. Research Servi Charleston, S. Carolina, U.S.A.
3521s	2939	
3522s	3092	
3523s	3162-3-A-1	
3525s	3162-3-A-2	
3526s	3289-4-2-1	
3527s	3289-4-3-1	
3528s	3291A	
3529s	3291B	
3530s	3295	
3531s	3305	
3532s	3323	
3533s	3357	
3534s	3359	

Group 2.

Acc. No.	Hawaii Ref.	
3500s	Hawaii No.1	Hybrids with the variety 'Anahu heterozygous for the gene 'M' conferring resistance to eelwor (gene ex L.peruvianum), but not necessarily Septoria resistant. From Dr. J.C. Gilbert, Hawaii Agric. Experimental Station. (Received October, 1958).
3501s	" No.2	
3502s	" No.3	
3503s	" No.4	
3499s	Anahu	

Group 3.

Acc. No.	Beltsville Ref.	
2796s	West African Resistant.	From Dr. W.S. Porte, U.S.D.A., Beltsville, Maryland, U.S.A. (Reported to be Septoria resistant). Received January, 1959).
2797s	Red Plum.	
2798s	Western Red.	
2799s	Turri Alba.	
2800s	Columbia Rain Resistant.	

Pusa Rabi — Samaru stock of widely grown Indian variety; probably having L.esculentum x L.pimpinellifolium parentage.

L 1706 — Large, rough fruited, locally grown variety collected from Bomo, Zaria Province (of unknown origin, collected June 1959); a widely grown locally variety.

(For the genetics of groups 1 and 2, reference should be made to the review by Rick (1956), p.301, entries 6 and 7 respectively).

Development.

Date of flowering of the first truss was unfortunately not recorded, although this is an important observation which should be taken for all tomato trials.

Leaf spot initials were first observed on 21 August 1959 on plants of 3162-3-A-1 and 3162-3-A-2. (As is explained later in the text, these initials did not develop).

Harvesting was conducted at three day intervals from 3 October 1959 to 29 October 1959. It was decided not to continue harvesting after this date owing to the early and sudden cessation of the rains at the end of September. Normally, sporadic rain and high humidities are expected throughout the month of October, under which conditions fruit and Septoria development would have continued longer. In 1959, both the 7 a.m. and 4 p.m. relative humidities were down to 20% at the end of October.

Yield.

Yielding ability of different varieties is affected by numerous factors other than Septoria susceptibility. In this particular analysis, yield pattern has been expressed as the percentage of the total yield of each variety maturing before and after 15 October. The significance of this will be seen on the interpretation of the results.

Assessment of Septoria Infection.

Scoring of infection was first carried out on 23 September and repeated on 21 October.

The leaves for scoring were chosen in relation to the growing point of the plant, leaf 'one' being that on which the leaflets were just expanding and the rachis had moved outward to 30^{o} or more from the main axis. Successively older leaves were termed leaf 'two', leaf 'three' etc. There is opportunity for some error between observers in the interpretation of leaf 'one'. However, 'observer' x 'variety' interaction was avoided by the use of one observer on the plot to cover all varieties at any one time

and a test between observers showed a disagreement for less than one plant in ten on the assignment of the developmenta class to a particular leaf.

The fourth, firth and sixth leaves were given an infection rating according to the following scale, which was based on observations on the development of infection previously described. To assist the observers, a chart was prepared from typical leaf specimens showing the areas of spottir and necrosis characteristic of each infection stage, of which fi were recognised.

The chart illustrating Stages 1,2 and 3 is shown in Figure 1.

The features of the different grades of infection are summarized in the table below.

Table II.

Characteristics of the different grades of leaf infection in terms of number of foci, presence of chlorosis and necrosi

Infection Grade	Spotting	Chlorosis	Necrosis
0	Nil	Nil	Nil
1	+	Nil (At least of	Nil
2	++	+ (terminal	Nil
3	+++	++ leaflet)	+ (Terminal leaflet onl
4	+++	+++	++(Terminal and lateral leaflets)
5	(Necrosis of all leaflets. Necrosis extending to the petiole, or complete death and possibly abscission, of the leaf).		

RESULTS.

Septoria Development.

The susceptibility scoring, taking the average of the three leaves and the average 'plant value' of the twelve plants, varied from 0.8 to 5.0 at the first scoring and from 1.9 to 5.0 at the second scoring. The early onset of the dry season diminish the value of the latter scoring and increased the errors of estimation.

Analysis has therefore been concrentrated on the first scoring via the scoring ten days before the commencement of ripening. It is, furthermore, the susceptibility at this stage which one would suspect to be the cause of loss of leaf area and hence loss in yiel

Distribution of scoring is illustrated in Figure 2.

It will be seen from the scatter of scorings that there is not a simple bimodal distribution. There is a discrete 'susceptible' class composed of the 'Hawaiians'. At the second scoring a number of Group 1 lines have progressed to the intermediate or susceptible classes leaving between four and six lines, depending on the interpretation, which retain their resistan

Fig. 1.

Diagram of infection grades in the development of Septoria lycopersici.

Stage '0', not illustrated, represents complete freedom from infection. Stage 4 differs from stage 3 in the anount of necrosis and chlorosis (see text table II). Stage 5 is fully necrosed.

FIGURE 2

DISTRIBUTION OF SEPTORIA SUSCEPTIBILITY RATINGS BETWEEN THE DIFFERENT GROUPS OF VARIETIES.

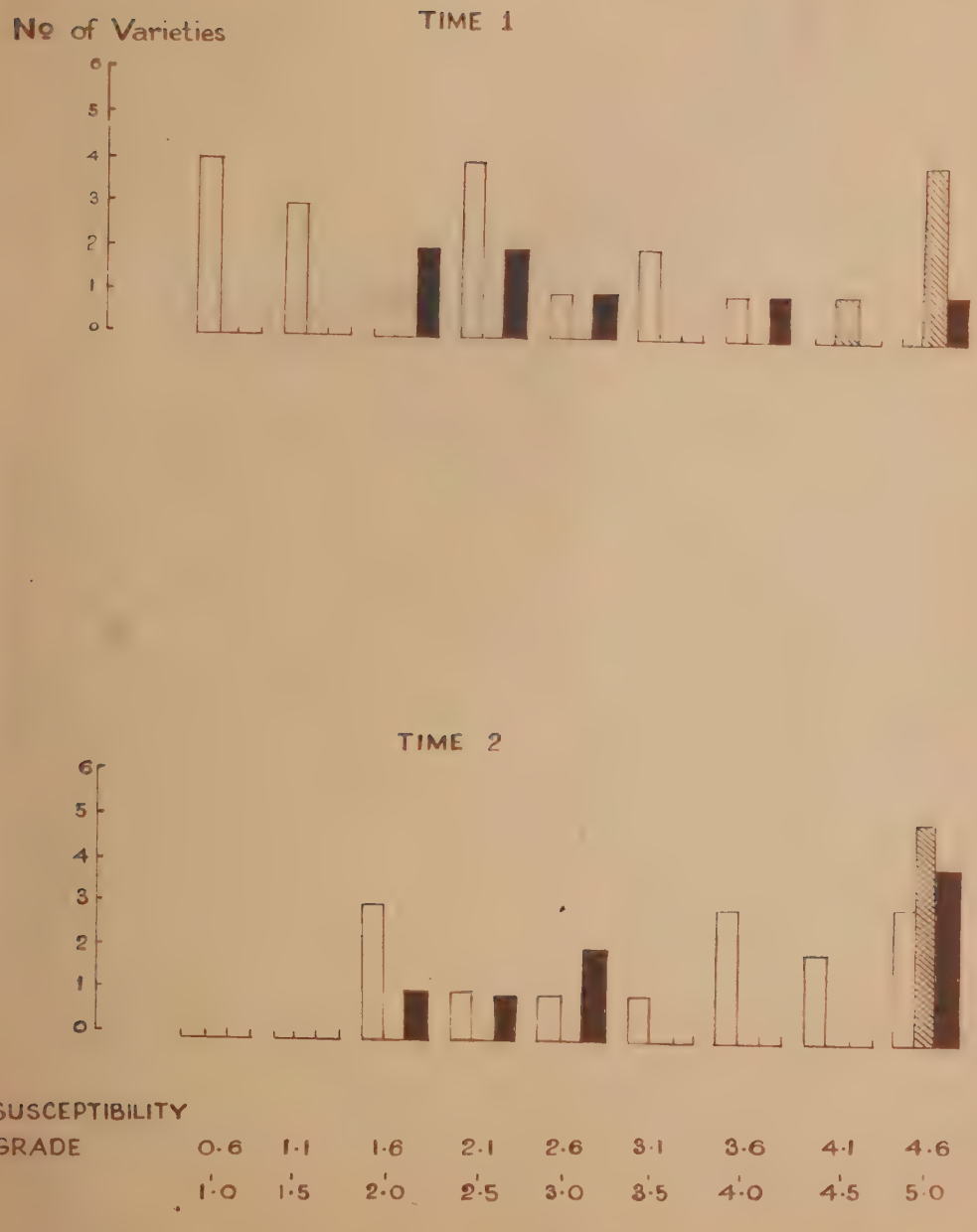


FIGURE 3

CHANGES IN SUSCEPTIBILITY AS SHOWN BY INFECTION SCORES ON LEAVES OF DIFFERENT AGES AND DIFFERENT SCORING TIMES.

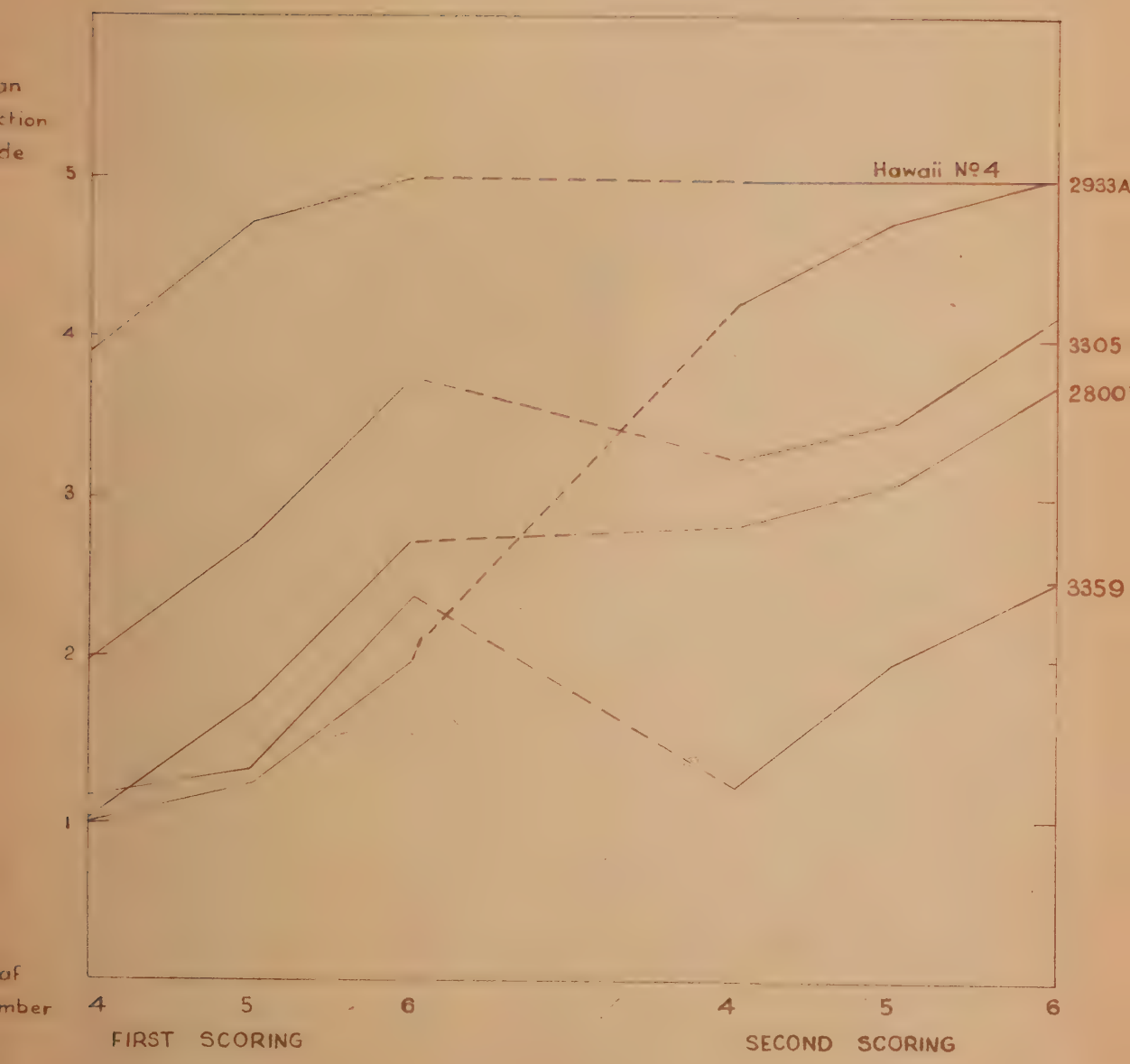
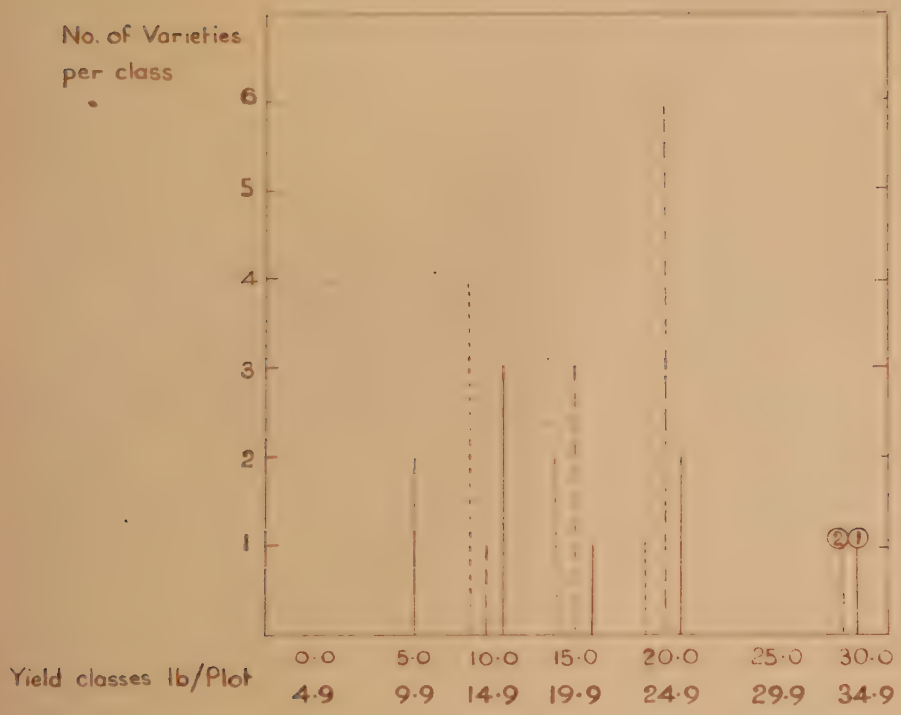


FIGURE 4

GENERAL GROUPING OF VARIETIES ACCORDING TO YIELDING ABILITY AND SEPTORIA SUSCEPTIBILITY RATING.



KEY:
① 3162-3-A-1
② 2939

SEPTORIA REACTION

(For Details of this Classification, see Text)

This pattern of behaviour is consistent with the genetic situation as summarised by Rick and Butler (1956). The features of this are:-

(a) More than one strain of Septoria is known to exist in the U.S.A. (these may all be different from the West African strains).

(b) Resistance is in the form of suppressed lesion development in which the lesions on resistant forms develop few or no pycnidia.

(c) The gene 'Se' is incompletely dominant and Rick and Butler, quoting from Lincoln and Cummins, and MacNeill, state that classification is good only with a pure strain of pathogen under ideal environmental conditions.

Differences in degrees of resistance can also be illustrated from the differences between mean scorings on successive leaves of the different varieties. This is shown in Figure 3. In this figure, the progress of the disease is demonstrated on selected varieties from the mean leaf scoring on the sequence of three leaves at times one and two. The progress of infection of Hawaii No.4(hybrid) is typical of that of fully susceptible varieties. Its parent 'Anahu' had a scoring of '5' on leaf '4' even at the first scoring date. 2933A (Group 1) exhibits the characteristics of a 'delayed onset' susceptibility, which would be of value in the field if for some reason more resistant types could not be used. Typical of the partially resistant types are 3305 and 2800s of Group 3 (Columbia Rain Resistant, ex Beltsville). Fully maintained resistance is shown by 3359 (Group 1), the repetitive form of the curve showing the close relationship between scoring and the developmental stage of the leaf.

This analysis demonstrates that care is required in detecting resistant genotypes due to genetical causes in addition to the normal 'errors' of variation in time of onset, inoculum density, and plant position (affecting microclimate and soil) which are accepted hazards of field investigation of pathogen resistance.

Yield.

Since the layout was systematic, absolute yield was confounded with 'position'. However, an approximate illustration of the distribution of total yields in relation to susceptibility is given by Figure 4. In this figure, the varieties have been classified: fully resistant R-R where the mean infection rating did not exceed '3' at either scoring: delayed onset R-S where the infection rating did not exceed '3' at the first scoring: susceptible S-S where the infection rating exceeded '3' at both scorings.

It would be unjustifiable to deduce too much from these yield figures, but the yields of the two S.Carolina lines ((1) and (2) in the figure) are noteworthy.

Yield pattern, that is the distribution of yield in time in relation to development (the yield fractions being expressed as percentages of the total yield of the line) is, however, capable of demonstrating a correlation between a rapid decline in yielding ability and increase in infection of susceptible plants. In fugure 5 this correlation has been expressed as:-.

'That percentage of the yield of the variety which ripened after 15 October 1959 (angularly transformed for analysis purposes) as a variable dependant on the Septoria infection-rating of the variety as assessed on 23 September 1959". In other words, what is the relationship between yield and Septoria infection during ehe period when the particular trusses are developing?

Table III

Significance of the linear form of the regression illustrated in Fig.5.

		Analysis of variance		
Item	df	SS	MS	VR
Regression	1	0.101	0.101	
Deviation	25	0.300	0.012	8.41
Total	26	0.401		

Equation:- $y-0.527 = -0.064(x-2.722)$

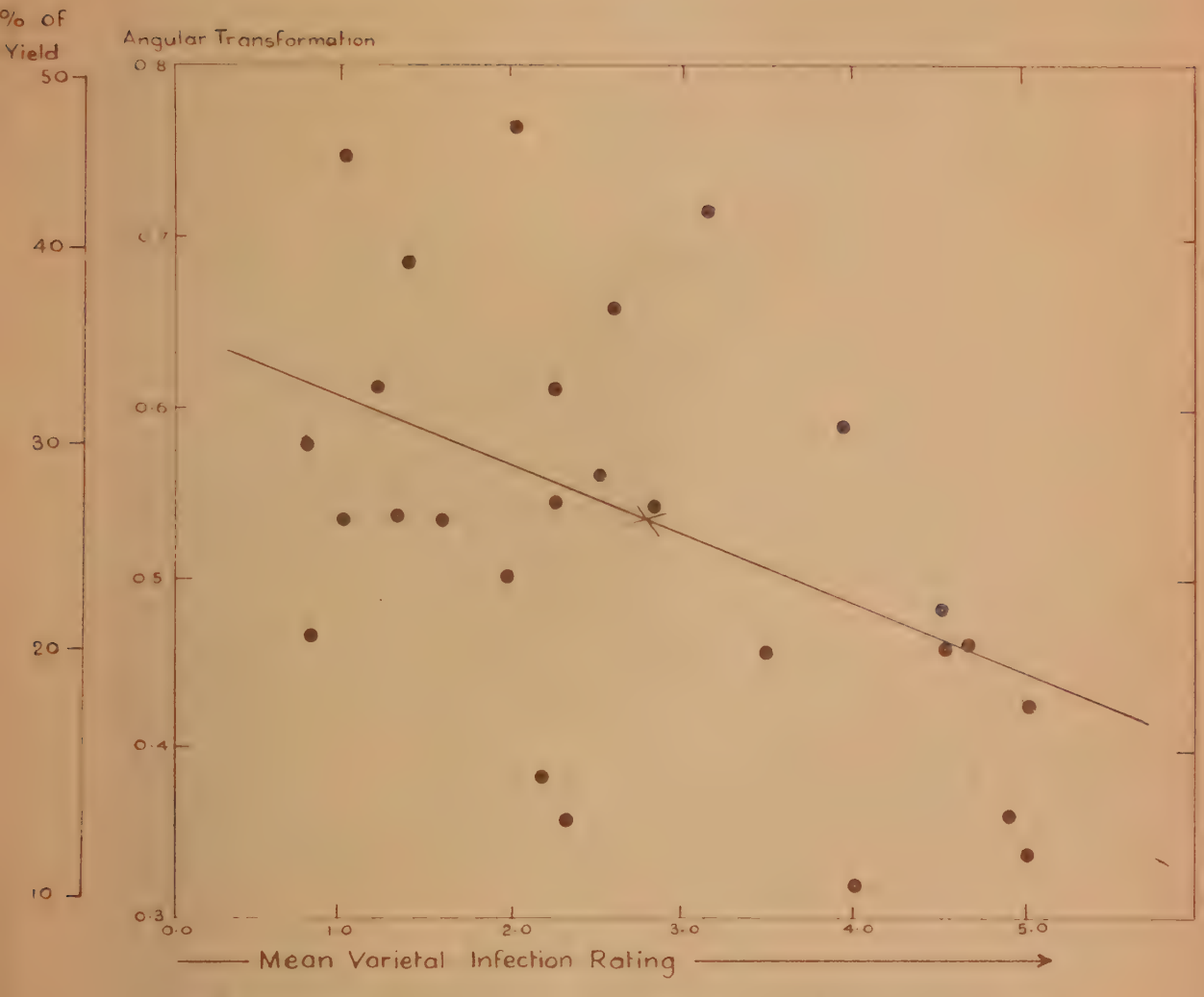
The liner form of this regression is highly significant (Table III) and presents clearly the quantitative effect of infection with this particular pathogen on yield. The slope of the regression indicates that every increase of 1.4 units of infection causes a loss of yield of 5% under the circumstances of the experiment. Thus the difference between a susceptible and resistant variety is approximately 15% and this loss is cumulative. That is, had culture permitted the ripening of later trusses the yield values would have been increasingly in favour of Septoria resistance. Conversely, had trial in been planted earlier, thus giving a longer growing season, the effect of Septoria resistance would have been even more marked.

DISCUSSION

Model systems for the study of the genetics of host-pathogen interactions are difficult to find. Using the methods described herein, it is suggested that the Septoria - tomato system is amenable to study by comparatively simple methods for the purpose of analysis of genetic differences in a given environment and of epidemiological phenomena, using genetically pre-determined lines, in a varying environment. The indeterminate habit of the lines used is of advantage in that it presents a regular series of developmentally uniform host organs to the infective agent.

FIGURE 5

EFFECT OF EARLY INFECTION OF SEPTORIA LYCOPERSICI ON THE ABILITY OF DIFFERENT VARIETIES TO CONTINUE FRUIT PRODUCTION.



THE DIAGRAM ILLUSTRATES THE LINEAR REGRESSION FOR THE PROGRESSIVE LOSS OF YIELDING ABILITY WITH INCREASING DEGREES OF SUSCEPTIBILITY. DETAILS OF THE ANALYSIS OF VARIANCE OF THIS REGRESSION ARE GIVEN IN THE TEXT.

It is therefore particularly useful in Nigeria, where the lack of information on the environment is noteworthy, to have a simple biological measuring system which can collect information on the spot without the intervention of highly trained workers or complex apparatus. A check is easily introduced into the system by requesting that sample leaves are returned to the central laboratory, labelled with the local assessment, for confirmation of the assessor's rating of the infection grade and for confirmation that the observed condition is due to the causal organism under study.

Systems involving detailed description of lesions, as used by MacNeill for instance, would be difficult to apply to the present type of investigation and, further, the known instability of symptom pattern is an added difficulty in the use of this type of assessment.

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* A full bibliography is being prepared as part of the studies in the 1960 growing season of the application of the technique reported here.

Ade.Jnr.